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AN EXPERIMENTAL FIELD TEST OF THE VALUE OF SELF-TUTORING MATERIALS IN HIGH SCHOOL PHYSICS. INTERIM REPORT.

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VARIOUS ASPECTS OF THE DEVELOPMENT AND USE OF SELF-INSTRUCTIONAL MATERIALS WERE REPORTED. MATERIALS WERE DEVELOPED TO COVER 6 WEEKS OF INSTRUCTION IN THE SECOND SEMESTER OF HIGH SCHOOL PHYSICS. APPROXIMATELY 3,000 INDIVIDUAL QUESTION-AND-ANSWER FRAMES WERE INCORPORATED INTO THE MATERIALS. TO DETERMINE THE CONTRIBUTION OF THE MATERIALS TO STUDENT ACHIEVEMENT, COMPREHENSIVE EXAMINATIONS COVERING NINE INSTRUCTIONAL UNITS WERE CONDUCTED. THE SUBJECTS CONSISTED OF APPROXIMATELY 450 STUDENTS IN 15 HIGH SCHOOLS WHERE PHYSICS FILMS (TELECAST DAILY OVER EDUCATIONAL TELEVISION STATIONS IN PITTSBURGH) WERE USED REGULARLY. COMPARISONS OF RESULTS WERE MADE OF CLASSES WHICH RECEIVED THE SELF-INSTRUCTIONAL MATERIALS, SUPPLEMENTING THEIR REGULAR PHYSICS COURSE, AND THE CLASSES WHICH RECEIVED ONLY CONVENTIONAL INSTRUCTION. THE PRELIMINARY RESULTS INDICATED THAT SELF-INSTRUCTIONAL MATERIALS MADE A SIGNIFICANT CONTRIBUTION TO THE LEVEL OF ACHIEVEMENT ATTAINED BY THE SUBJECTS. FURTHER PLANS OF THIS PROJECT WERE SUMMARIZED. RELATED REPORTS ARE ED 003 205 THROUGH ED 003 207, ED 003 214, ED 003 215, AND ED 003 655 THROUGH ED 003 659. (RS)

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SELF-INSTRUCTIONAL SUPPLEMENTS

FOR A

TELEVISED PHYSICS COURSE

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AN INTERIM REPORT

AMERICAN INSTITUTE FOR RESEARCH
Pittsburgh, Pennsylvania

AN EXPERIMENTAL FIELD TEST OF THE VALUE OF SELF-TUTORING MATERIALS IN HIGH SCHOOL PHYSICS*

An Interim Report of Progress and Preliminary Findings

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April 1960

*The research reported herein is supported by grant No. 736022.90 from the United States Office of Education, Department of Health, Education and Welfare, under Title VII of the National Defense Education Act of 1958. The full title of the project is "Increased Learning from TV Courses by Use of Integrated Self-Scoring Instructional Quiz Materials and 'Practice Machines'."

ABSTRACT

This report describes the progress in development of self-tutoring materials and preliminary findings from initial field tests, obtained in a study conducted by the American Institute for Research. This study is being sponsored by the United States Office of Education under Title VII of the National Defense Education Act, to assess the effectiveness of applying recently developed self-instructional techniques in ongoing instruction. Its specific objective is to determine the contribution made to achievement in high school physics by use of materials employing self-tutoring techniques.

The report describes and illustrates the self-tutoring materials developed by the research staff to cover approximately six weeks of instruction in the second semester of high school physics. The self-tutoring materials developed for this project comprise approximately 3,000 individual question-and-answer "frames," to each of which the student is able to respond appropriately as he learns from the materials at his own rate of speed.

Preliminary results reported are based on comprehensive examinations covering the first nine units of the self-instructional material. These results include test data from approximately 450 students in 15 schools in Western Pennsylvania which are regularly utilizing the Harvey White physics films, telecast daily over stations WQED and WQEX in Pittsburgh.

Preliminary Findings: Comparison of results for experimental classes to whom the self-instructional materials were made available to supplement the physics course (as compared with control classes who did not receive the self-tutoring materials) demonstrate that the self-tutoring materials have made a significant contribution to the level of achievement attained by participating students. The magnitude of the increase in achievement is great enough to conclude that, when properly written, self-instructional materials represent an encouraging development in educational procedure.

Further plans under this project are also summarized in the report.

Basic Plan of Study

A comprehensive overview of the approach and experimental design of this project, sponsored by a grant from the United States Office of Education under Title VII of the National Defense Education Act, has been presented in a previous report (Klaus and Lumsdaine, 1959).[1] In this earlier report, it was pointed out that recent developments in self-tutoring techniques and devices suggest the possibility of increasing the proficiency attained by students from a high school course in which televised lecture-demonstrations are a principal source of instruction. It was suggested that this could be done by contributing to those aspects of instruction which are not optimally suited to televised presentation and which tend to be at least partially neglected in many classrooms because of the large size of the classes. Specifically, it was expected that self-tutoring techniques could be systematically employed to provide the properly sequenced and thoroughgoing individual practice necessary for increased mastery of the subject matter.

The specific objective of this study is the systematic evaluation of self-instructional physics materials as they would be used extensively under realistic field conditions. The choice of high school physics as the subject matter for this study was based on its recognized importance and on the availability of a set of filmed lectures, being transmitted locally over television, which insured that each student would be exposed to a common core of material. This standard in course content made it possible to provide an experimental test of the effectiveness of the specially prepared self-instructional materials in a controlled situation which is, nevertheless, a typical classroom environment.

The self-instructional materials used in this study consist of carefully organized sequences, or "programs" of questions and answers. Each question-and-answer segment is called a "frame." The materials are designed so as to require that the student respond actively to each frame. He is then promptly furnished with the correct answer which provides verification or correction of the response he has given. By proceeding to develop the student's skills with the subject matter in very small steps, these materials insure a very high level of correct responding as they continue to subtly expand the student's knowledge to the point where he is making very complex responses accurately and easily.

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[1] Klaus, D. J. & Lumsdaine, A. A. Self-instructional supplements for a televised physics course: Study plan and experimental design. Pittsburgh: American Institute for Research, December 1959.

By experiencing frequent and regular reward for making correct responses, the student is likely to learn difficult concepts more rapidly and retain his newly acquired knowledge for a longer period of time than he would otherwise do. As has been noted by Skinner (1958)[2] and others, this procedure resembles that used by a good tutor, who allows the student to practice in such a way that he gradually, but systematically, develops a proficiency in the subject matter.

The part of the study which is reported here has two major aspects. The first of these has been the preparation of extensive self-tutoring materials. Sequences of frames were written for a sufficiently large portion of the high school physics course to provide a full-scale test of their utility in practical instruction. The second aspect of the study consists of the experimental field test designed to assess the utility of the self-tutoring materials -- or, more specifically, to determine whether their use will yield a significant increase in achievement when used in connection with ongoing high-school physics courses.

The particular combination of TV instruction supplemented by self-tutoring materials had special implications for the design of this study. At this time, it is not assumed that anywhere nearly all phases of instruction would be fully handled by these self-instructional techniques. Many important aspects of teaching, for instance, depend on the student's observing a complex demonstration. For the current study, this aspect of instruction was provided over TV by the Harvey White series of filmed lecture-demonstrations. In all the classes used, the teachers supplemented these televised programs to varying degrees by classroom demonstration, lectures, and laboratory work. Thus, all the students participating in this study received a regular, full course of instruction even when they were not provided with the specially developed materials.

Development of Self-Instructional Materials

A total of almost 3,000 self-tutoring question-and-answer "frames" were written, tried out on samples of students, revised, reproduced, and distributed to schools. These self-tutoring materials cover approximately six weeks of the second semester of high school physics in the areas of electricity and light (optics). The construction of these materials has followed a rationale and

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[2] Skinner, B. F. Teaching machines. Science, 1958, 128, 969-977.

procedure described previously in some detail by Klaus and Lumsdaine (1959)[3] and characterized in general terms by Lumsdaine (1960).[4] In general, this procedure included an analyses of the subject matter, as defined by the content of the Harvey White films, writing the sequences of instructional frames, trying these out with individual students, having them checked for technical accuracy by a physicist consultant, editing and revising the materials, and in many cases, carrying out a further cycle of try-out and revision to perfect the materials. The resulting sequences of frames are so structured that at each step nearly all students make the appropriate responses to each frame, and they proceed to develop and practice more and more complex concepts and relationships as they progress through the material.

The blocks of course content utilized in the experimental design consist of four sections of high school physics: Electricity I (Static Electricity and DC Circuits), Electricity II (Magnetism, Electromagnetism and Alternating Current), Light I (the Nature and Reflection of Light), and Light II (Refraction of Light and Optical Instruments).

No self-instructional materials were constructed for Electricity II, which represented a control topic. For each of the other three topics, self-instructional materials were used by approximately half of the available classes. The self-tutoring materials developed for this study were organized into units to facilitate their use. These blocks of materials are listed below.

Block A: Electricity I -- Static electricity and direct current.

A total of 1,204 frames were developed, comprising nine units of work, as follows:

Unit 1	Static electricity and electrical charges	142 frames
Unit 2	Coulomb's Law, conduction and induction	124 frames
Unit 3	Distribution of charge and flow of current	104 frames
Unit 4	Difference of potential	124 frames
Unit 5	Batteries and circuits	97 frames
Unit 6	Resistance and resistors	154 frames
Unit 7	Potential divider and Wheatstone Bridge	123 frames

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[3] op. cit.

[4] Lumsdaine, A. A. The development of teaching machines and programmed self-instruction. In, New teaching aids for the American classroom. Stanford University, California: Institute for Communication Research, 1960. pp. 136-173.

Unit 8	Electrical field and capacitance	117 frames
Unit 9	Electrostatics and electric currents review	219 frames

Block C: Light I -- Nature and reflection of light.

A total of 826 frames were developed, comprising six units, as follows:

Unit 1	Light sources and the rectilinear propagation of light	120 frames
Unit 2	Photometry and the velocity of light	127 frames
Unit 3	Reflection of light, image formation and multiple reflection	120 frames
Unit 4	Reflection from curved surfaces	155 frames
Unit 5	Polarization, diffraction and interference	145 frames
Unit 6	Photometry and reflection review	159 frames

Block D: Light II -- Refraction of light.

A total of 809 frames were developed, comprising six units, as follows:

Unit 1	Refraction and index of refraction	128 frames
Unit 2	Snell's Law, total reflection and prisms	116 frames
Unit 3	Lenses, focus and focal points	105 frames
Unit 4	Image formation	145 frames
Unit 5	Aberrations, the eye and magnification	152 frames
Unit 6	Refraction and lens review	163 frames

In addition to these frames on physics, each student was also provided with an introductory section of materials which included step-by-step instructions as to what he was to do; as well as a special refresher unit on mathematics. This section briefly covered topics such as simple algebraic manipulations and geometrical constructions in 89 frames. Altogether, these units complemented 28 televised lessons (or, roughly six weeks) in the areas of electricity and light from the Harvey White physics films. These films were transmitted over television channels 13 and 16, through the facilities of Pittsburgh's educational TV stations WQED and WQEX, five days a week to the participating classes.

The nature of the self-tutoring materials written for this project is difficult to convey adequately by means of short exerpts. The materials are designed to be suitable for presentation in any of several forms of "teaching machines" or similar modes of presentation. In the phases of field work thus far completed, the self-tutoring frames have been presented in book form, (called "programmed texts"), with the correct answer portion of any one frame always presented on the following sheet of the book, so that the student can check the answer or answers he has given by turning the page. After checking his response, he then goes on to the succeeding questions which appears on the following page, and so on through the book. The books were arranged with the

pages ruled off in parels in order to conserve space, so that after working through a set of some 20 or 30 frames, the student was to turn the book around and proceed back, a sheet at a time, on another panel of frames.[5]

The writing, tryout and revision of the self-instructional materials was a very large undertaking. It was found that the average amount of time required per frame was approximately 1/2 hour -- including original writing, checking for technical soundness with a consultant, tryout, revision, further tryout, and final revision -- up to the point of reproduction of final copy. Thus a total of about 1500 professional man hours was required to produce the materials.

These materials represent perhaps the most extensive single application of self-tutoring techniques thus far carried out. In addition, the field study for evaluating these materials in practical instruction is the only extensive field test of its kind that has thus far been conducted.

The scope of this work can best be illustrated in terms of the physical attributes of the resulting materials. Each participating student was furnished with up to five, inch-thick loose-leaf notebooks of self-tutoring materials. Overall, three and one half tons of paper were used in reproducing the materials and, even though each three-ring binder was used several times, it was nonetheless necessary to provide 120 dozen of them to participating schools.

The way in which students learn from these self-tutoring materials can be seen from the illustrative sequence of frames shown in Figures 1, 2, and 3. These samples may give some conception of the manner in which both specific knowledge and generalized concepts were developed and gradually extended in such a way as to insure that the student, working at his own pace, practiced using each term, concept and relationship in a variety of contexts and applications of increasing complexity -- thus, developing a thorough working command of the subject matter. It may be noted that the first few frames in the sample given are quite easy, but that before long the student progresses to material of considerable complexity which he can nevertheless continue to deal with easily and effectively.

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[5] For some of the subsequent experimentation, it is planned to present the same materials on microfilm with the aid of a special presentation device.

Concerning Figure 1:

The illustrative sequences on following sheets are intended to simulate, in part, the manner in which the individual student is exposed to the Question-and-Answer panels of successive frames in a self-tutoring program.

The reader may wish to follow this sequence, answering each question, starting at the top of Figure 1 on the next page. He may wish to write in the answer for each question in the box or may merely supply each answer mentally before checking his answer and proceeding to the next frame.

The asterisk (*) in some of the response boxes is a convention that was used to inform the student that the required answer consists of more than one word. A double asterisk (**) is used in later frames to show that the student should supply an extended answer, using his own words.

To best follow the progression of illustrative question-and-answer frames for this Figure and for Figures 2 and 3, it is suggested that, in beginning, the reader cover all but the topmost panel (A-1) with a card or sheet of paper, thus successively disclosing each answer panel (as, a-1) only after filling in the preceding answer box.

FIGURE 1

A-1

A very important discovery in physics was the mutual attraction of objects due to static electricity. If we rub a hard rubber comb with a wool cloth and hold it over bits of tissue paper, the comb will attract the paper. This attraction illustrates [ ] electricity.

---

a-1

static

A-2

At parties, you have probably seen someone rub balloons against a wool rug to make the balloons stick to the walls or ceiling. This is another example of [*].

---

a-2

static electricity

A-3

In [ ] electricity, some objects will attract each other. A hard rubber comb rubbed against wool will [ ] bits of tissue paper.

---

a-3

static

attract

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(continued in FIGURE 2: go on to next page)

FIGURE 2

A-4

Still another example of static electricity can be seen when a piece of amber that has been rubbed with silk will [ ] small objects.

---

a-4

attract

A-5

Static electricity can also cause objects to repel each other. When a comb rubbed through fur is brought near another comb rubbed through fur, the combs will not attract each other but will [ ] each other.

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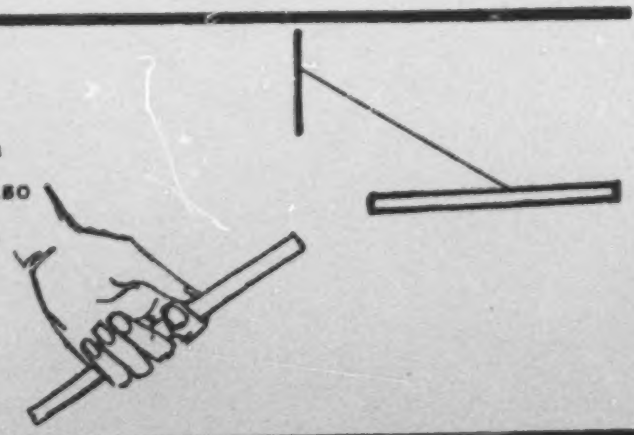
a-5

repel

A-6

Knowing that two rubbed combs will repel each other, you would predict that two amber rods would also [ ] each other after they have been rubbed.



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a-6

repel

A·I·R ©1960

(concluded in FIGURE 3: go on to next page)

Concerning Figure 3:

Following Frame A-6 at the bottom of Figure 2 (on the preceding page), about 25 frames intervene which are not shown in this report. As he responds to these two dozen frames, the student develops familiarity, in varied contexts, with the concepts "attraction," "repulsion," "charge," "positive," "negative," "like charges," "unlike charges," and so forth.

To finish these intervening 25 frames requires perhaps 10 minutes for a bright student, and as long as 20 or 25 minutes for a slow student; but both the quick and the slow students are able to respond, with consistent correctness, to a range of questions of increasing difficulty.

By the end of the brief sequence which is concluded by the three frames shown on the next page in Figure 3, the student is not only able to state in his own words the general rules for attraction and repulsion of electrical charges, but has acquired a rich context of meaning and understanding of the concepts involved through repeatedly employing them in appropriate contexts.

FIGURE 3

A-31

Two positive charges are "like charges" so they repel each other. A negative charge and a positive charge are [*] and they attract each other.

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a-31

unlike charges

A-32

The general rule is that [ ] charges attract and [ ] charges repel.

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a-32

unlike

like

A-33

The general rule for attraction and repulsion is that [**].

---

a-33

like charges repel and unlike charges attract (or you could say, unlike charges attract and like charges repel).

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Conduct of Experimental Field Tests

For the experimental phase of the study thus far completed, the self-tutoring materials for one or more blocks of materials (Electricity I, Light I, Light II) have been distributed to nine high school physics classes in the greater Pittsburgh area. In addition, half a dozen classes have also participated in the study as a control group which did not receive the self-tutoring materials. (Half of the classes in the control group were, however, supplied with conventional workbooks designed to accompany the televised physics lessons.)[6]

The 16 classes available for use in this phase of the study comprised approximately 420 students in 15 different high schools. Represented were six school districts in Allegheny County (Pittsburgh) and neighboring communities. Combining the two classes in one school, 15 separate groups were available for conduct of the main part of the study.

Of the nine "experimental" classes, three classes received all three blocks of the available self-tutoring materials (Electricity I, Light I and Light II); three classes received the first and last blocks (Electricity I, Light II); and three classes received only the middle unit (Light I). One of the reasons for using this experimental design was to provide, in addition to the overall assessment of their contribution to achievement, a check on whether the value of the self-tutoring materials is sustained over a period of extended use, or whether the effectiveness is diminished, for the classes that use the whole series, after the initial novelty effect wears off.

All classes (both control and experimental) had, in addition to whatever materials were supplied through this study, the benefit of: (a) daily instruction via TV, (b) a classroom teacher, (c) their regular textbook and, in many of the classes, (d) a supplementary text or laboratory manual. For most of the classes, laboratory instruction, classroom demonstrations, classroom films, and other instructional resources were used regularly by the teacher.

Since this portion of the study was designed as a field test rather than a laboratory experiment, every effort was made to allow the teacher as much

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[6] The total of 16 classes included in the control and experimental groups comprised the only 16 classes in Western Pennsylvania which could be located which regularly watched the Harvey White TV presentations. Earlier estimates based on preliminary reports from the schools had indicated a considerably larger population of classes using the programs, but it turned out that many of these only watched an occasional program rather than watching the series regularly.

freedom as possible in the conduct of the class. Each student in the experimental group was given a copy of the self-tutoring materials for his own use, and the teachers were instructed to encourage the students to use them. However, teachers were asked not to systematically check student progress on the special materials, nor to correct or grade the materials, prepare tests on the basis of the materials, or in any other way to compel the students to use the materials. This meant that students in most cases continued to receive other assignments from their teacher, in addition to using the experimental, self-tutoring supplements. Thus students could, when they wished to do so, omit the supplementary self-tutoring materials from their study routine.

As of the date of this report, the self-tutoring materials on the two blocks of units in optics (Light I and Light II) are now in use in the experimental classes. The nine units of material on electricity have been completed, in accordance with the schedule of TV lessons regularly being transmitted over WQED and WQEX. Comprehensive criterion tests on block A (Electricity I: Static Electricity and Direct Current, which was covered by over a thousand frames of self-tutoring materials for the experimental classes) were administered in mid-April, about two weeks after the conclusion of this portion of the course. At the same time, similar tests were administered to all 16 of the classes covering also the "control block" of material (Electricity II: Magnetism and Alternating Current), which the classes had finished studying just before the administration of the tests.[7]

The criterion tests covering the content of the corresponding two blocks of televised lessons were constructed by an independent testing agency (Educational Testing Service) on the basis of the TV scripts. This procedure avoided any possible bias to the results which could have resulted had the same personnel constructed both the self-tutoring materials and the criterion tests. Similar tests on light will be given after the experimental and control classes have completed the sections of the course dealing with optics (Light I and Light II), and near the end of the semester, the College Entrance Examination Board (CEEB) achievement test covering the entire content of the physics course will be administered.

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[7] Thus, any experimental bias resulting from a decrement in retention would tend to favor measured attainment of the control block of course content.

Wherever possible the experimental procedures were deliberately designed to give the benefit of any doubt so as to favor the control groups over the experimental groups. It was felt that this way the effectiveness of the special materials could be most conclusively explored. It was for this reason that students were not required to use the materials, but only encouraged to do so. Furthermore, the tests were built such that perfect scores were obtainable from viewing the TV lessons alone; hence, they avoided the possibility of giving any preferential treatment to students who had been supplied with the self-instructional materials.

Preliminary Findings

Preliminary analysis of the data for the first set of tests (on Electricity) has now been completed. The results of the preliminary analysis represent, basically, a comparison of experimental classes (which had the self-tutoring materials available for use) versus the control classes (which did not have the special materials available for use). The crucial analysis was a comparison of the difference between experimental and control groups for the block of nine units on Electricity I for which the experimental self-tutoring materials were used by the experimental classes. In making this comparison, an appropriate correction was introduced to equate for differences in aptitude based on the performance of classes on the block of units (Electricity II) for which neither the control or experimental groups had the self-tutoring materials.

Using this differential index of proficiency to assess the contribution to achievement in knowledge of physics, the three control classes which received conventional workbook materials showed no significant superiority over the six control classes who did not receive any supplementary material. These conventional workbooks were originally prepared by Harry Wolff for the University Extension Division of the University of Wisconsin to aid students in getting more from the films than they might ordinarily do. Each lesson, corresponding to a single TV film, contains a special "Study and Restudy" reading passage, a list of "Things to Watch for in the Film," and a "Self-Test" which the student is to complete. The inclusion of these materials as part of this study was to establish whether amount of time spent in study was a critical consideration. Since the preliminary data indicates no increase in achievement with these workbooks, it can be more certainly concluded that any effect produced by the special self-tutoring materials was not due to any increase in the amount of time which

the student devoted to studying the subject. (It should be noted, however, that this study is not a fair test of the Wolff materials for their intended use as supplements to home viewing of the Harvey White series).

Because of lack of achievement differences in the two control sub-groups, they were combined in the subsequent analysis. The main comparison, then, was between the combined control groups and the experimental groups, that is, between the nine classes not receiving the special self-instructional materials and the six which did. Results of this crucial comparison showed a clear margin of superiority, representing a statistically significant improvement in proficiency in physics, as a result of having the experimental self-tutoring materials available for the course units on static electricity and DC circuits (Electricity I).

At a minimum, on the basis of present results, it can be confidently concluded that the self-tutoring materials supplied produced a tangible and decided increment in the average level of subject-matter proficiency attained by the students. This conclusion is supported by the extremely stringent test of statistical significance used, in which the estimate of experimental sampling error was based on observed variability from class to class, in accordance with the way the experimental treatments were actually assigned, rather than by the inappropriate application, frequently employed in educational research, of a significance test in which the experimental error is estimated from the total number of individual students employed.[8]

Based on this rigorous statistical test, the value of the t-ratio obtained was 2.34, which indicates that the obtained margin of superiority of the experimental group in the expected direction could have arisen, as a result of chance sampling errors, less than two times in a hundred.

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[8] Such a test would, despite its rather common use in the literature, have afforded an unsure basis for testing the significance of a field experiment such as the present one, in which experimental treatments are assigned to intact class groups. The appropriate and more rigorous test here employed utilized only 13 degrees of freedom, based on 15 observations, each corresponding to the mean test score for one of the 15 classes used in the experiment. See:

Lumsdaine, A. A. Audio-visual research in the U. S. Air Force. Audio-visual Commun. Rev., 1953, 1, 76-90.

May, M. A., & Lumsdaine, A. A. Learning from films. New Haven: Yale Univ. Press, 1958.

Lindquist, E. F. Design and analysis of experiments in psychology and education. New York: Houghton-Mifflin, 1953.

These results are based on a preliminary analysis of data employing mean scores computed using all the items included in the criterion tests. Refinement of the test through item analysis procedures, currently in process, will provide more sensitive measures, and will yield mean scores which may, of course, differ considerably in absolute numerical value from those used in this preliminary analysis. However, this refinement, while it should afford a better estimate of the exact margin of contribution made by the self-tutoring materials, cannot reasonably be expected to alter the basic conclusion as to the effectiveness of self-tutoring materials. If anything, we should expect the relative superiority of achievement resulting from the supplemental use of the self-tutoring materials might show up even more strongly with the more refined measures.

No factual statement is possible at the present time, of course, concerning the contribution of the corresponding self-tutoring materials for the other blocks of material (Light I and Light II), pending the administration and analysis of data from the tests covering these units of the course.

Further Work

Completion of Analysis for this Phase of the Study

As indicated above, a more refined analysis will be made of the data both for the block of material (Electricity) for which test results are thus far available, and also for the subsequent test results from the field study of 15 schools for the blocks of material on Optics. Further analyses will also be conducted to indicate the proportion of students of attaining different levels of mastery with and without the benefit of instructional materials for various strata of aptitude.

Phase Two

The second of two phases of field work being conducted during the current semester was not envisaged in the original study plan but has been incorporated into the study partly as a result of the relatively small number of schools found to be making regular use of the TV physics programs. In surveying schools, an opportunity was discovered to expand the application of supplementary self-instructional materials to school systems where television was not in use. Two comparable schools were found, each of which had five physics classes, all taught be the same instructor. It was decided to use these classes, comprising some 250 students, for a second phase of the study. In this second phase, the contribution of the self-tutoring materials is being investigated as a supplement to

regular classroom instruction not accompanied by televised lessons. In this portion of the study, each of the 10 classes in the two schools, regardless of group, will receive the regular instruction provided by their teacher, will use an assigned textbook, and will have assigned additional work. Some classes will be furnished with self-tutorial materials, however, to be used in the same way as they were in the first phase of the study.

In addition, it has been possible to modify the routine practice in each of these two schools for a short section of the course. In each school, Block D (Light II) is being used in place of classroom lectures (rather than as a supplement) for two of the five classes. For this one unit, it will thus be possible to assess the level of achievement in physics which can be attained by use of the special self-tutoring materials, without any classroom lectures, as compared to that attributable to conventional teacher-and-textbook form of instruction.

It is expected that by reducing the amount and variety of instruction given in addition to the special self-tutoring materials, it will be possible to more accurately gauge the amount of learning actually attributable to these materials. In the first phase of this study, the higher attainment of experimental classes represents an increment of achievement over and above what they would have learned without the special materials. Since the students were already rather thoroughly exposed to the content of their course through at least three (television, teacher, and textbook), and often more, forms of instruction, it is likely that the results so far obtained tend to underestimate the effectiveness of these materials for educational purposes.

Phases Three and Four

The third planned phase of the study will involve the application of self-instructional techniques to laboratory work in physics, while the fourth planned phase will study the use of mechanical devices to present programmed self-instructional materials. It was decided that these phases of the study would necessitate too extensive a modification in ordinary classroom routine and approved curriculum to permit extended application in established physics classes. As an alternative, therefore, steps have been initiated to organize "science club" groups in several high schools, where students will participate in these phases of the study on a voluntary basis.

Phase Three of the study will employ a specially prepared self-instructional program in basic electronics. Participating students will be supplied with kits

of electronic parts, in conjunction with their self-instructional programs, so that actual laboratory work can be carried out under the guidance of the self-tutoring sequences.

Phase Four of the study will test the relative effectiveness of self-instructional materials when presented by a mechanical device instead of with a printed book. This device will make possible the greater control of the learning sequence than can be achieved with the "programmed-text" format used in Phases One and Two of this study, where the student was at liberty to omit sections, review previous work, peek ahead, and so forth. For this phase, it is hoped that advanced materials in "modern" (atomic) physics will be developed. These materials will, in content, go considerably beyond the level of difficulty and complexity normally covered in a high school course, but which can, it is believed, be successfully taught to high school students by use of appropriate self-tutoring materials.